



Department for
Business, Energy
& Industrial Strategy

NATIONAL MEASUREMENT SYSTEM

Annual highlights 2016/17

October 2017



Spherical roller bearing in 3D printed referencing frame used to improve the service lifetime of systems used in wind turbines.

Contents

Measurement matters – an introduction	5
Investing in a world-leading measurement infrastructure	6
Ensuring good policy, standards and regulations	8
Getting better connected to our end-users to deliver impact	10
Improving the UK’s measurement skills	12
Providing confidence in the intelligent and effective use of data	14
National Measurement System	15

Investing in a world-leading measurement infrastructure



Ensuring good policy, standards and regulations



Our vision is for the UK to capitalise on its world-leading National Measurement System to be the best place to live and do business.

Confidence in the intelligent and effective use of data



Getting better connected to our end-users to deliver impact



Improving the UK's measurement skills



Measurement matters – an introduction

Every time you use your GPS, put petrol in your car, or receive a medical diagnosis, you are putting your trust in measurements that are underpinned by a system that ensures they are both reliable and internationally recognised.

The UK National Measurement System (NMS) is comprised of a core infrastructure of measurement laboratories that are connected with the wider measurement community of service providers that ensure you can have confidence in the measurements you make or are made on your behalf.

Our reliance on the NMS is often overlooked, but, like many of our infrastructures such as roads or water, it would be noticed if it failed. The fact that it is invisible to many is indicative of its success, but our economy, our quality of life and often our very lives depend on the robust and reliable measurements it enables.

This document provides some highlights of the activity and impact of the NMS from 2016/17.

The use of good measurement practice is proven – a recent study found clear evidence that companies who use NMS services have higher survival rates and support from the NMS can boost employment by **10% - 15%** within two to four years; with an average cost to the state of **£18k to £23k** per job.

The Impact of Public Support for Innovation on Firm Outcomes, BEIS Research Paper 3, March 2017

Investing in a world-leading measurement infrastructure

The NMS manages a dynamic portfolio of measurement capabilities. These ensure the UK sustains an internationally-leading measurement infrastructure and science base, and responds to the national challenges where better measurement will play a central role in delivering successful outcomes.

During the last year an independent **International Science Review** assessed the quality and relevance of the science output of the larger NMS laboratories. The Review Panel, consisting of 32 worldwide experts, concluded that all the NMS science areas perform at an internationally-competitive level and more than half of the NMS science areas are considered to be internationally-leading.

The **NMS scientists and engineers are experts** in their own right and, as such, publish papers, present at conferences and receive awards and appointments that reflect their scientific standing. In 2016, our scientists published 337 papers in peer-reviewed scientific journals, including: *Physical Review A*, *Nature*, *Journal of the American Chemical Society*, *Nature Communications*, *Metrologia*, *Scientific Reports*, and *Philosophical Transactions of the Royal Society*. Our scientists also received over 43 notable awards and appointments from external bodies.



437

different measurement services delivered to over 731 different customers



337

papers in peer reviewed journals, 43 notable awards and appointments

For long-term metrology research **we must work in partnership**. In the past year, the NMS laboratories have had 445 active academic partnerships to deliver key priorities. These have included:

- Applying capabilities to help the UK become the world leader in the development and commercialisation of quantum technologies, as a partner in the **UK National Quantum Technologies Programme**. As well as creating unique testing facilities for the early adopters of this technology, we are also creating new quantum-based devices.
- Securing a major investment from **Scottish Enterprise** and **TUV-SUD** for the new Centre of Excellence for Subsea Development, providing a new high-pressure high-flow multiphase flow national standards facility. The new infrastructure will deliver new calibration services and enable research that industry is demanding.
- Working with **Cancer Research UK** in their inaugural Grand Challenge competition to create a 'Google Earth' view of tumours to help beat cancer sooner. The research will transform how cancer is diagnosed and treated by creating a reproducible, standardised way to fully understand different tumours in unprecedented detail. The multidisciplinary team includes researchers from Imperial College London, Beatson Institute, AstraZeneca, the Francis Crick Institute, the Institute of Cancer Research, Barts Cancer Institute and the Cancer Research UK Cambridge Institute.
- Delivery of a new micro-vibration testing facility to the **European Space Agency** supporting the growing space sector. The micro-vibration platform can measure vibrations made by subsystems to an unprecedented degree of accuracy – so sensitive it can measure the force of a single dropped feather. The platform is the latest addition to ESA's test centre in the Netherlands and has already assessed the performance of a solar array drive mechanism for the forthcoming Meteosat third generation satellites.
- The opening of a joint centre for Nonlinear Microwave Measurements and Modelling at the **University of Surrey** to respond to the needs for 5G infrastructure testing and validation. The centre is the world's first multiphysics-enabled facility dedicated to nonlinear microwave measurements and modelling to ensure that the next generation of wireless technology is highly energy efficient.
- The launch of a new instrument with pharmaceutical company **GlaxoSmithKline**, 3D OrbiSIMS, for world beating label-free molecular imaging responding to one of the major challenges in the pharmaceutical industry. This instrument will help identify where drugs go at the cellular level, even within specific organelles, answering long-standing questions about whether drug concentrations are sufficiently high in the right places to have a therapeutic effect, or if the medicine is lodging within cellular components and causing toxicity.
- Partnering in **University College London's new Future Targeted Healthcare Manufacturing Hub**. The Hub will address manufacturing, business and regulatory challenges to ensure that new targeted biological medicines can be developed quickly and manufactured at a cost affordable to society.
- The NMS also actively participates in the **European Metrology Programme for Innovation and Research**, currently leading 34 collaborative projects and partaking in 33 more across a wide range of programmes. One project is developing a new measurement system for the next generation of automated manufacturing. Operating in a similar way to global navigation using GPS, an early prototype of the system was successfully demonstrated in a live factory environment during a two-week measurement campaign at **Airbus's** Filton site.

Ensuring good policy, standards and regulations

Good measurement brings confidence to data and the decisions that are based upon them. The NMS must be coordinated to ensure good measurement, and standards are at the heart of evidence-based policy and regulation.

Government and associated agencies rely on the trusted expertise and **advocacy of the NMS** to provide advice on technical aspects and impact of policies in health, security, energy and the environment, as well as for specific emergency responses. For example, this year the Government Chemist team developed a pioneering new DNA test that is able to distinguish between almond and mahaleb – a spice made from the seeds inside cherry stones – to resolve a scientific dispute referred by the Food Standards Agency (FSA). Following the resolution, the FSA was able to rescind the product recall, restoring confidence in the product and minimising income losses for the manufacturer.

Measurements enable trade between suppliers and customers. Combining traceable measurement with accreditation can build trust between buyers and sellers, once you have trust in the system. This trust is at the heart of trade in commodities that can be bought and sold very rapidly without any inspection. Supporting this are around **1,500 accredited calibration and testing laboratories in the UK that are reliant upon the UK Measurement Infrastructure** as their reference point. This broader National Quality Infrastructure which embraces standardisation, accreditation, and conformity assessment will be a key element as we look to build new trading arrangements in preparation for leaving the European Union.

The NMS partners delivered 437 different measurement services to over 731 different customers. Their impact is considerable. In just one example, a single service delivered to GE Grid Solutions Ltd (a developer of systems, equipment and services for the railway sector) provided calibration services for approximately 50 organisations and around 2,500 instruments, which are traceable back to nationally-held standards.

Globally comparable measurement standards are also essential for exports and international supply chains. Therefore, the NMS represents UK interests in over 300 standards committees to ensure the UK can successfully compete. In the past year, the NMS has supported the publication or amendment of 70 standards, including:

- Successfully leading the development of an ISO standard for multiphase flow meters: a key goal for the Oil and Gas Authority.
- Being instrumental in developing a new standard that represents a global consensus for reference material production, which has taken two years and significant international effort to achieve.
- Leading the development of best practice on control of bioprocessing materials, and contributing to standards on guidance for cell counting methods and their statistical analysis to improve the quality control and safety of cell-based products, supporting a more rapid progression of cell based therapies.
- In addition, the NMS has supported the preparation and distribution of new International Standards (biological reference materials) for the control and measurement of biological activities. In 2016, the World Health Organisation (WHO) endorsed new materials in the areas of cancer, infectious disease and other clinical/therapeutics measurements.

Where regulation does not yet exist, standards and **measurement techniques can provide a sound basis for principles of safety, compatibility and reliability**. This year the NMS has:

- Worked with the Nuclear Decommissioning Authority (NDA), improving the speed and accuracy of analysis to provide better information for nuclear waste management plans. The technique significantly reduces the procedural time and labour required for analysis, reducing site clean-up time and offering significant economic benefits to nuclear sites.
- Coordinated the most extensive comparison of digital polymerase chain reaction – a technique to replicate DNA sequences. The inter-laboratory study involved 21 independent end-user laboratories. Results will support the development of clinical methods for the detection of rare sequence variants, for example in cancer or prenatal diagnostics, and in monitoring of transplant organ rejection or infectious diseases.

World-leading, competitive industries innovate rapidly to take products to market. They require absolute confidence in these products in order to trade. This **confidence is underpinned by the ability to measure and prove conformance to standards**. Agreeing on and implementing high-quality standards and the associated measurement infrastructure is an essential part of the UK becoming or maintaining its internationally leading role in a sector. In the past year the NMS has launched 32 new services to support industry, such as:

- A time service for the financial sector ahead of new regulations.
- An underwater calibration service to meet new environment regulations and guidelines which aim to protect wildlife from the negative impacts of noise from shipping, offshore energy exploration, construction and other activities.
- A high-pressure flow national standard, identified by the Oil and Gas Authority (OGA) and related to the use of meters in service conditions.



70

newly published or amended standards supported by the NMS



In the past year the NMS has launched

32

new services to support industry

Getting better connected to our end-users to deliver impact

We are driven by understanding our end-user requirements and ensuring ever-increasing access to our measurement knowledge, products and services. To do this we have **created a range of mechanisms for users to engage with the NMS**.

We actively open the doors of our facilities and deploy our people to work in partnership to aid the exchange of knowledge. In the past year the NMS has:

- Engaged with over 494 organisations throughout the world
- 445 partners in NMS-funded projects
- 32 individuals on secondments both into and out of the laboratories

Some great examples of the NMS getting better-connected from the last year:

- Our Product Verification Programme (PVP), in its third year, has supported 76 companies with end-to-end measurement health checks and subsequent support across the advanced manufacturing value chain. Within 45 of these companies £10.5M cost of quality improvements were identified and two companies have received £27M worth of orders attributable to this support.

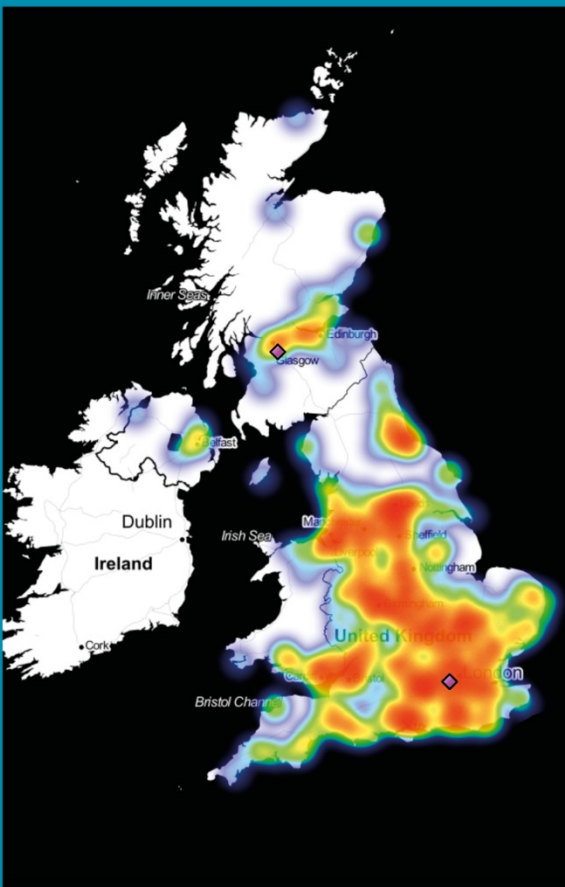
“The market is tough, but thanks to PVP support we are now winning on innovation, speed, quality and efficiency” - John Townsend, Managing Director, Stone Foundries.

- The Flow Measurement Institute, launched in 2015, now has over 700 members and promotes NMS, academic and industry collaboration. In 2016, the Institute published a comprehensive forward look of research requirements over the next 10 years across 10 market sectors in a partnership with editorial guidance from leading industry personnel.
- In January 2017, we launched the first **Analysis for Innovators Scheme in partnership with Innovate UK and the Science and Technology Facilities Council**. Over 90 companies submitted measurement-related challenges for consideration and there are now 31 contracts in place to provide direct support from the NMS laboratories. The companies' initial self-assessed benefits of the programme are over £350M.

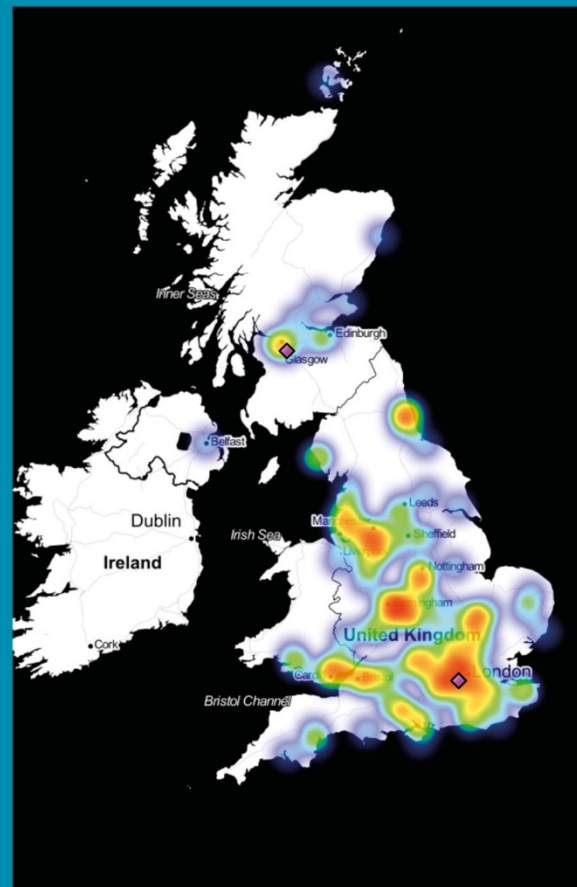


The **NMS has a significant pool of knowledge that is shared** through measurement products and services, reference materials and artefacts, events, conference attendances, publications, best practice guides, online resources and other support aids for users.

The **reach of the NMS is nationwide**. The maps below show the geographic spread of companies using our measurement services and where our collaborators reside.



In 2016, the NMS laboratories successfully delivered measurement services (including calibration, testing and analysis services and/or the provision of traceable reference materials and artefacts) to customers in 919 locations across the UK. The geographic distribution of customers is shown in the heat map, with red areas representing locations with the highest density of customers, and blue the lowest density.



NMS collaborators were defined as institutions or companies that co-authored peer-reviewed publications with the NMS laboratories, participated in grant-funded projects, shared staff members (such as secondments and students), or partnered with the NMS in inter-laboratory studies. In 2016 there were 326 UK-based collaborators; their locations are depicted on this heat map, with red areas representing locations with the highest density of collaborators, and blue the lowest density.

Improving the UK's measurement skills

Skills are an important priority for the UK and a key pillar in the UK Industrial Strategy. Technical skills are essential for creating the absorptive capacity required when adopting innovative new technologies and processes.

As processes become more automated, investment in leading-edge equipment is vital, and this is the same with measuring equipment used across a huge range of applications such as enforcement control, medical applications, manufacturing and scientific discovery. However, the appropriate practical measurement skills and a thorough understanding of basic measurement concepts are being lost as the workforce becomes more reliant on automated systems. Companies and organisations large and small are realising that the lack of measurement skills is an issue for their workforce.

To address the broader issue, the **NMS is taking a leadership position** in developing skills capabilities for the future. In this year successes include:

- Since its formation in 2015, the Flow Measurement Institute has had three principal themes: skills development, research and infrastructure, each with an industry-led steering group. The skills team, led by Emerson, has focused on building a comprehensive approach to training and education needs for the oil and gas sector.
- The Department for Education (DfE) approving the trailblazer apprenticeship standard for Metrology Technician. The NMS led a consortium of 30 employers to design a new Level 3 standard that sets out the knowledge, skills and behaviours required by Metrology Technicians across a wide range of industries. This is the first nationally-recognised apprenticeship standard in metrology; it will ensure apprenticeship training is relevant and beneficial to the future of the metrology industry.

“Apprenticeships offer young people a **ladder of opportunity** to gain the **vital skills** they and businesses need to **succeed**. By putting more control in the hands of employers, we are ensuring apprenticeships are **high quality** and address skills shortages facing industry. Congratulations to the metrology trailblazer for publishing their Metrology Technician apprenticeship standard, and for playing an active role in developing the **workforce of the future**.”

Responding to demand, the **NMS runs a broad range of specialist training programmes**. The NMS trained 1,189 people in 2016, and this year marked the 10,000th student through the dimensional measurement training programme. New courses and initiatives launched this year include:

- The first learners to complete the **new Diploma in Metrology and Calibration** which offers technical education leading to skilled employment, approved by EAL, a skills partner and awarding organisation for industry; this provides an alternative to the academic route.
- A **new Measurement Science Training Programme**, for the 250 students in the Postgraduate Institute for Measurement Science, launched to provide a foundation for good measurement practice to support students during their doctoral research.
- The first 20 students receiving training on a new course, developed with UKAS, on **Evaluating Measurement Uncertainty for Chemical Testing Laboratories**, required as part of a standard (Medical laboratories – Requirements for quality and competence).
- The NMS offering **five online training courses**, and 2,620 learners completing a course in 2016.
- The laboratories **hosting PhD students**: 35 students successfully defended their PhD theses in 2016.



1,189

people trained across

57

training courses



2,620

*learners, in the past year,
completing a course online*

Providing confidence in the intelligent and effective use of data

The world is getting ever more interconnected, with networks of sensors and other instruments making more measurements and making them more frequently than ever before. The digital revolution has brought with it the ability to generate, combine and manipulate huge quantities of data, but more data does not necessarily increase their value.

This growth area for the NMS is looking at the **quality, reliability and integrity of data to ensure appropriate decisions are made from them**. The NMS must create the measurement framework required for traceability in big data systems. Quality assurance enables confidence in the intelligent and effective use of data, increasing the value of information and ensuring the robustness of decisions made on data analytics. The NMS expertise in the rigour of analysis in physical measurement can be applied to digital systems to meet these goals, through the provision of data standards and verified data processing methodologies, generating unbroken chains of data flow with quantifiable uncertainties at each step.

A UK Workshop on Data Metrology and Standards marked an important step in evaluating the challenges and needs of UK, and was attended by 90 industrial users of data to identify data measurement challenges and explore research project ideas. The most pressing industry challenges identified during the workshop were:

- Decision-making from multiple sources of information - quantification of data quality to assure high quality decision-making
- Machine learning for data processing and analytics and associated quality indicators
- Standards for archival data, metadata and searching of data
- Sensor technology – standardisation of sensor metadata, storage of sensor datasets, encryption of data to individual sensors, and validation and governance of data from sensor to analytics
- Reliable methods for combining data streams with different characteristics (data type, uncertainty, etc.)
- Methods for propagating uncertainties through data curation methods and data analytics
- Training of UK data scientists to meet current and future industry needs
- Management, use and learning from historical, legacy or available data
- Improved provenance of measurements, data and databases (and Internet of Things)
- Ethics of data collection and use on a large scale
- Certification of trusted algorithms

The aim of the new data initiative is to be a business-focused partner, providing pre-competitive and bespoke research, and developing standards with enduring value and use. The NMS has now commissioned a programme of work to start to address some of these.

National Measurement System

The Department for Business, Energy and Industrial Strategy (BEIS) is responsible for the UK government’s annual £65 million investment in the National Measurement System.

The UK, along with all other developed countries, invests in measurement infrastructure to allow measurements to be made with integrity and consistency by developing and maintaining internationally-recognised measurement standards and practices. At its core, the NMS ensures that measurement in the UK is consistent with the global common system of measurement units: the International System of Units – the SI (Système international d'unités).

The common SI system of units underpins much of the daily use of measurement in the UK, but there are also many areas of measurement such as in chemistry, biology and food science which are needed beyond this formal system. These areas are often where new measurement knowledge needs to be developed to tackle emerging needs.

The government provides the funding to support this infrastructure, engaging experts from academia and industry to provide independent advice on the science programmes carried out by the laboratories. This also guarantees that the capabilities are available to all in the UK: from those contributing to the quality of our lives in education, health or security, to those supporting our economy through manufacture and trade.

The UK National Measurement System is comprised of a core infrastructure of measurement laboratories that are connected with the wider measurement community that includes international, legal, quality science and innovation, to deliver the benefits of measurement to the UK end-users.

NPL	National Physical Laboratory	the UK’s National Measurement Institute
LGC	formerly Laboratory of the Government Chemist	designated for chemical and biometrology
NEL	formerly National Engineering Laboratory	designated for fluid flow metrology
BEIS	Regulatory Delivery (Department for Business, Energy & Industrial Strategy)	designated for legal metrology
NGML	National Gear Metrology Laboratory	designated for gears metrology
NIBSC	National Institute for Biological Standards and Control	designated for bioactivity metrology



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